The Volendam Fire: Lessons Learned from Disaster Research

Sabine M. van Harten, MD;[1] Joost J.L.M. Bierens, MD, PhD;[2] Lieke Welling, MD;[3] Peter Patka, MD, PhD;[4] Robert W. Kreis, MD, PhD;[5] Maarten Boers, MSc, MD, PhD[6]

1. Department of Surgery, Zaans Medical Center, Zaandam, the Netherlands
2. Department of Anesthesiology, VU University Medical Center, Amsterdam, the Netherlands
3. Department of Surgery, Academic Medical Center, Amsterdam, the Netherlands
4. Department of Surgery, Erasmus Medical Center, Rotterdam, the Netherlands
5. Burns Centre, Red Cross Hospital, Beverwijk, the Netherlands
6. Department of Epidemiology, VU University Medical Center, Amsterdam, the Netherlands

The Ministry of Health funded this study.

Correspondence:
Sabine M. van Harten, MD
Zaans Medical Center
Department of Surgery
Koningin Julianaplein 58
1502 DV Zaandam
The Netherlands
E-mail: svanharten@hotmail.com

Keywords: burns; design; disaster; evaluation; fire; framework; inhalation injury; medical care; methodology; protocols; research; Volendam

Abbreviations:
CRF = case report form
ICU = intensive care unit
MERV = Medical Evaluation of the Disaster in Volendam
TBSA = total body surface area

Received: 18 July 2005
Accepted: 17 October 2005
Revised: 25 January 2006

Web publication: 12 October 2006

Abstract

Introduction: After the Volendam fire, a multidisciplinary, integral evaluation, called the Medical Evaluation of the Disaster in Volendam (MERV), was established. This article is a discussion of disaster research methodology. It describes the organizational framework of this project and the methodological problems.

Methods: A scientific steering group consisting of members from three hospitals prepared and guided the project. A research team wrote the final study protocol and performed the study. The project was funded by the Ministry of Health. The study protocol had a modular design in which each of the modules focused on one specific area or location. The main questions for each location were: (1) which treatment protocols were used; (2) what was the condition of the patient; and (3) was medical care provided according to existing protocols. After the fire, 241 victims were treated in hospitals; they all were included in the study. Most of the victims had burn injuries, and approximately one-third suffered from inhalation injury. All hospitals and ambulance services involved were visited in order to collect data, and interviewers obtained additional information. The government helped obtain permission for data-collection in three of the hospitals. Over 1,200 items of information about each patient and >200,000 total items were collected. During data processing, the data were re-organized, categorized, and presented in a uniform and consistent style. A cross-sectional site analysis and a longitudinal patient analysis were conducted. This was facilitated by the use of several sub-databases. The modular approach made it possible to obtain a complete overview of the medical care provided. The project team was guided by a multidisciplinary steering group and the research was performed by a research team. This enabled the research team to focus on the scientific aspects.

Conclusion: The evaluation of the Volendam fire indicates that a project approach with a modular design is effective for the analysis of complex incidents. The use of several sub-databases makes it easy to combine findings and conduct cross-sectional and longitudinal analyses. The government played an important role in the funding and support of the project. To limit and structure data collection and analysis, a pilot study based on several predefined main questions should be conducted. The questions then can be specified further based on the availability of data.

van Harten SM, Bierens, JJLM, Welling L, Patka P, Kreis RW, Boers M: The Volendam fire: Lessons learned from disaster research. *Prehosp Disast Med* 2006:21(5):303–309.

Introduction

Recent disasters have attracted the attention of different professionals, and disaster investigation now occurs with increasing regularity. Disaster research is important as it can help improve facilities for future disasters, contribute to the preparedness of medical intervention, and inform the population on the quality of care that has been provided.[1–3] However, most investigations of disaster situations only provide incomplete descriptions of the health care provided or selected aspects of medical care in disaster situations (e.g., a selection of

patients or parameters).[4–13] The Disaster Health Studies Group, installed after the Oklahoma City bombing in 1995, performed multidisciplinary and integral research.[3]

After the Volendam café fire, the government installed a special committee to investigate the cause of the fire and an organizational framework for the disaster response (Committee of Inquiry—café fire, 01 January 2001).[4] Meanwhile, two university hospitals and the regional burn center expressed interest in investigating the medical aspects of the event. On the initiative of these three hospitals, a unique, extensive, multidisciplinary, and integral evaluation was performed. The evaluation was called the Medical Evaluation of the Disaster in Volendam (MERV). This article is a discussion of the disaster research methodology used for the evaluation. It describes the organizational framework of this project and the methodological problems encountered.

Methods

Description of the Disaster

Event—On 01 January 2001, a fire occurred in a café in Volendam, a small fishing village located about 20 kilometers from Amsterdam. More than 350 children and young adults from 13–27 years of age were closely packed inside of the café when the short blaze occurred. The temperature in the room reached 400° Celsius (752° F).[4]

Response—Immediately after the fire began, many volunteers, ambulance crews, family doctors, and mobile medical teams arrived on-scene to assist with the rescue and provide medical treatment. A total of 241 victims were brought to 19 hospitals in the surrounding area by nine ambulance services. Three mobile burn triage teams were formed to support the hospitals involved with the initial treatment, and to establish the need for secondary referrals. During the following days, 78 patients were re-triaged and transported to other national and international hospitals to receive the most appropriate level of care. Most patients (71%) were transferred within 48 hours. A total of 36 hospitals were involved in treating the victims, including 11 burn centers in the Netherlands, Belgium, and Germany.

Initial Study Proposal

Soon after the fire, three hospitals expressed their interest in exploring various aspects of the quality of care provided. These aspects included: (1) the efficacy of medical treatment by the medical teams at the site of the event and in the emergency departments; (2) the impact of the sudden increase in the patient load on the ongoing patient care; and (3) the efforts by the burn teams to optimally distribute the burn victims between the 36 hospitals (national and international burn centers, university hospitals, and general hospitals). Based on advice from the Ministry of Health, these initiatives were combined into MERV. The variety of study aspects were combined and re-ordered into one study protocol using a modular design. The initial eight modules included: (1) the effect of the on-site organization on the care provided; (2) the impact of the disaster on the regular medical care provided in the hospitals; (3) the medical assistance provided at the site of the event; (4) the stabilization of patients in the emergency departments; (5) the treatment in the intensive care unit (ICU); (6) the interhospital transport of patients; (7) whether optimal medical care was provided; and (8) whether any deaths were preventable. The Ministry of Health funded the study, and a deadline for reporting to the government was set.

Research Team

A multidisciplinary, scientific steering group was installed in order to prepare and guide the project. This group included anesthesiologists and surgeons from the three participating hospitals, a clinical epidemiologist, and a representative of the local health authorities. After the scientific steering group had received formal approval for funding, a research team was formed and a Project Coordinator was appointed. The study was performed by four junior researchers. Three senior researchers were appointed to provide supervision part-time. The project team also included four research assistants, a data manager, six data typists, and a secretary (Figure 1).

Object Design

The researchers re-ordered the initial modules and developed a final study protocol. The final protocol also contained eight modules (Table 1). The question of whether any deaths were preventable was abandoned because the quality and quantity of data would be insufficient for a balanced answer for each deceased victim. Two extra modules concerning the medical care provided in the general wards and the logistical and financial impact were added. For each of the different locations in the medical chain (event site, emergency department, general wards, and ICU) the initial questions to be answered were:

1. Which treatment protocols were available?;
2. What was the condition of the patient?; and
3. Was medical care given according to existing protocols?

The credentials of the care providers in each location and their familiarity with the protocols also were investigated. The interhospital transport module contained questions concerning reasons and consequences of the transports. Furthermore, questions related to the costs and extra personnel in the hospitals and questions related to the overall mortality and outcome were included. These questions then were enhanced further and final research questions were formulated (Table 2).

Medical Ethical Approval

The Medical Ethics Committee of one of the academic hospitals approved the final study proposal. A letter was sent to the victims to inform them about the evaluation project and they were allowed to refuse the use of their medical data. If they had any questions, they could contact the Support Center for the Volendam victims (the "Anker"), which was established shortly after the fire.[5] The participating hospitals and ambulance services were informed and asked for permission for data collection. Three hospitals initially were not willing to cooperate, partly due to the fear of offending privacy legislation.

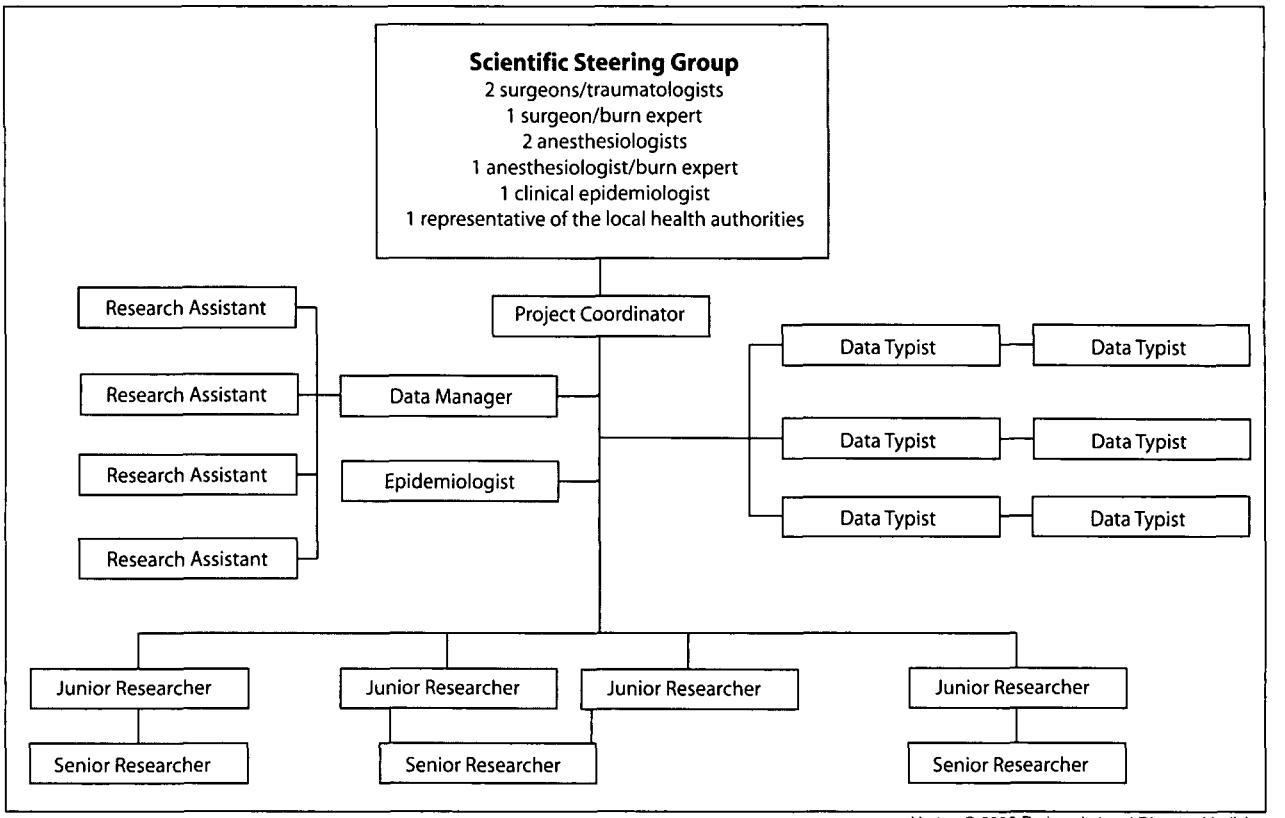

Figure 1—Organizational chart for the MERV project group

1. Organization at the disaster site
2. Medical care at the disaster site
3. Medical care in the emergency departments
4. Medical care in the intensive care units
5. Medical care in the general wards
6. Interhospital transports
7. Logistic and financial impact
8. Outcome parameters

van Harten © 2006 Prehospital and Disaster Medicine

Table 1—Final modules used in the investigation

Finally, after government involvement, all hospitals agreed and data collection began.

Data Collection

All of the data required to answer the questions were inventoried and separate case report forms (CRFs) were developed for each step in the medical chain. By assigning a patient number to each victim, data from different CRFs could be combined. Research assistants were trained to collect the data and complete the CRFs. A list of included victims and hospitals was provided by the local health authorities and the Support Center. All 36 hospitals (both national and international) involved in treating victims as well as the nine ambulance services involved were visited. Medical files and ambulance registration forms provided all of the patient-related information. No patients were contacted directly. Information from the hospitals was checked and compared to the lists provided. Additional information, mostly concerning the triage and treatment protocols used, was obtained by interviewing with key personnel who were at the scene and in the hospitals. During data collection, patient identification was maintained in order to add data and check the collected information of different resources. When all of the collected data were assembled, patient identification data were deleted, only leaving the anonymous patient number. Databases were developed by the Data Management Department of one of the participating university hospitals using the SPSS 11.0 software package (SPSS® Inc, Chicago, Illinois, USA). Data were entered into the database twice and compared for accuracy by the data typists.

Results

After the fire, 241 victims were treated in hospitals, 182 (75.5%) were admitted to a ward or an ICU, and 78 (32.3%) of them ultimately were transferred to another hospital. The injury pattern was uniform. Most of the victims had sustained burn injuries, and approximately one-third suffered from inhalation injuries (Table 3). The data for all 241 disaster victims were included in the study according to the list of victims provided by the local health authorities. More than 1,200 data items about each patient

https://doi.org/10.1017/S1049023X00003927 Published online by Cambridge University Press

Initial module	The stabilization of the patients in the emergency department
↓	
Final module	The medical care in the emergency department
↓	
Main research questions	Treatment protocols?
	Condition of the patient?
	Medical care according to existing protocols
↓	
Final research questions	Did all emergency departments have protocols for the treatment of burn injuries?
	Were all care providers familiar with these protocols?
	How many care providers were available at the emergency departments?
	What was their level of education?
	How many patients were treated in the emergency departments?
	How long did they stay?
	Which medical data indicating the patient's condition were registered?
	Which treatments were provided?
	What was the condition of the patients arriving at the ICU?
	Was the triage in the emergency department adequate?
	Was medical care provided according to protocol?

van Harten © 2006 Prehospital and Disaster Medicine

Table 2—Example of the final research questions in a module (ICU = intensive care unit)

	n	(%)		n	(%)
Total number of victims	245	100	Burn injury*	221	86.1
Admitted to ED	233	95.1	Inhalation injury*	96	39.2
Admitted to ICU	112	45.7	Other injuries*	36	14.7
Admitted to ward	70	28.6	Deceased on-site	4	1.6
Secondary transport	78	31.8	Deceased in ICU	10	4.1

van Harten © 2006 Prehospital and Disaster Medicine

Table 3—Study population (ED = emergency department, ICU = intensive care unit)
*diagnosed in hospital

and >200,000 total items were collected. The data contained demographic parameters, physiologic parameters, injuries diagnosed at the three different hospitals, and treatment provided to the victims at these locations. During interviews with >50 local and hospital health workers, details were collected concerning the protocols used, collaboration, and specific skills employed. Some of the data elements collected were not relevant. This was true especially for the patients treated in the ICU, where extensive lists were made of the treatment and interventions provided. Only items that reflected the care at the site of the event, emergency department, and the outcome parameters were used. An important amount of data could not be collected for the initial phases of care. For example, 12 diagnostic variables that were relevant in all settings were examined, including: (1) suspicion of inhalation injury; (2) breathing fre-

TBSA %	Inhalation injury	No inhalation injury
None	1	25
<15	28	108
15–25	21	7
25–40	19	1
>40	27	0
Unknown	0	4

Table 4—Example of categorization of patients (n = 241): patients are divided in groups of severity of injury based on the Total Body Surface Area burned (TBSA) and inhalation injury

quency; (3) oxygen saturation; (4) systolic blood pressure; (5) heart rate; (6) body temperature; (7) Glasgow Coma Scale Score; (8) burns; (9) Total Body Surface Area (TBSA) burned; (10) percentage of second-degree burns; (11) percentage of third-degree burns; and (12) additional injuries. On average, >60% of these variables were missing for all patients with an ambulance record and in the emergency department records, decreasing to about 20% in the intensive care records.

Data Processing

Frequency tables of the data were analyzed and missing data were inventoried. The data were condensed and aggregated by transforming continuous data into categorical data. Clear definitions were given, and cut-off points were determined to be able to compare and analyze by groups. For example, the patients were assigned into groups by severity of injury based on the TBSA involved and the presence of inhalation injury in order to facilitate further analysis (Table 4). Standardized data could be presented uniformly and consistently. Each module had its own sub-database, which was derived from the complete database. However, all variables could be combined using the patient identification number. In this way, the database could contain large amounts of data, and the new sub-databases were easier to analyze using smaller amounts of computer memory.

Analysis

The diagnosis and treatment at each of the three locations (event site, emergency department, ICU) were analyzed cross-sectionally (for example, the number of patients at the scene suspected of having an inhalation injury and the number that was intubated at on-scene). A longitudinal patient analysis was conducted to relate the final diagnosis in the ICU or ward to the treatment at the scene, during ambulance transportation, and in the emergency department. For example, the number of patients that finally were diagnosed as having sustained an inhalation injury in relation to the percentage of patients that were intubated at each of the different locations.

During the analysis, it became evident that some of the predefined questions were not specific enough, which hampered the selection of available data. For example, in the emergency department, one of the research questions asked whether medical care was provided according to existing protocols. Because several hospitals used different protocols, this had to be specified further in order to provide an answer. It was decided to use the *Emergency Management of Severe Burns Course Manual* as a reference.[5] Then, for every step in the protocol, questions concerning diagnosis and consequent treatment were formulated. For example, "How many patients had burns >15% TBSA?" "Did all patients with burns >15% TBSA receive intravenous fluids?" The same cut-off points were used in each module to enable longitudinal analyses. The amount of missing data made it impossible to provide answers to some specific questions. However, by combining data, other relevant questions could be answered in the longitudinal analysis. For example, the accuracy of estimating the TBSA at the scene and the emergency department could be established by relating the data at these locations the final estimations conducted in the hospital.

Report and Published Articles

Due to the amount of missing data for some areas, only an indication of the quality of care could be provided. The questions that could be answered, relevant findings, and recommendations for future disasters based on these findings, were published in a report which was presented to the government.[6] In a second phase of this evaluation, several of these recommendations were outlined further and presented in a consensus process.[7] Certain aspects and findings of the evaluation have made their way into the peer-reviewed medical literature and several articles are planned to be published in the near future.[8–11] The recommendations of the consensus process are now considered for implementation by policy-makers and involved professional organizations.

Time Frame

There were a total of 29 months between the disaster in January 2000 and the publication of the report in June 2003 (Table 5). The first research proposal and approval by the government was realized within months. Then, a research team was formed. Several junior and senior researchers were appointed as well as a project coordinator, which also required several months. The funding of the project was received a month after the formation of the research team. Although no serious delays could be identified in either of the steps, in total, the formation of the research team and the funding of the research project required nearly one year. The final study proposal was completed, and after approval from the medical ethics committee, permission for data collection from the hospitals was obtained. Some delay was added because the three participating hospitals initially were unwilling to provide data. The government played a role in obtaining permission to access the records.

Discussion

Several lessons can be learned from this project. First, the modular approach: merging of the data in a modular man-

18 January 2001	One integrated proposal
May 2001	Integrated proposal accepted and funding approved by Ministry of Health
June 2001	Advertising for members of the Project Team
November 2001	Start Project Team
December 2001	Funding received
February 2002	First draft of Evaluation Protocol
March 2002	Approval of Ethics Committee
April 2002	Evaluation Protocol conmpleted
May 2002	CRF and database completed
June 2002	Collection of data in the hospitals
September 2002	Processing of data
November 2002	Data of initially non-responding hospital included
January 2003	First Report version
April 2003	Final Report version
May 2003	Proofs printed
June 2003	Report completed

Table 5—Time path of activities 2001–2003 (CRF = case report form)

ner was effective. The integrated and modular design of the study enabled researchers to separate the different aspects of the study and to allow the individual researcher to focus on certain issues. Each step in the medical chain was evaluated, and combining these findings made it possible to make cross-sectional and longitudinal analyses and provided a complete overview of medical care given to the victims. This was facilitated by the use of patient identification numbers and the use of several sub-databases. An advantage of the modular design was that when insufficient data were available for certain aspects of the study, other aspects of the study still could be conducted. Due to the multidisciplinary approach in the evaluation of the Volendam disaster, most aspects of medical treatment were included.

Another important aspect of the project was the separation between the organizational and scientific components. The Volendam project was guided by a steering group and performed by a research team. This enabled the research team to focus on the scientific aspects of the project, while the organizational aspects were covered by the steering group. However, at that time, most of the researchers and members of the steering group had limited experience with the descriptive, epidemiological analysis of large patient groups. This hampered progress at some stages. First, in the data collection stage, an insufficient number of selections actually were relevant to specific questions. Consequently, the number of parameters collected was unnecessarily large. Additionally, the questions often were too broad and it was difficult to find an answer. During the evaluation of a disaster, and in other fields of research, it is important to formulate specific and relevant questions.[1,2] To facilitate this, the steering group and research team should include experts who understand the methodologies used for disaster research and are able to define the most elementary questions related to the disaster. If possible, experts previously involved in disaster research also should be included.[1]

Early on, government involvement is crucial for the funding and support of a disaster research project. This was demonstrated after the Oklahoma City bombing, where the Disaster Health Study Group recommended involvement of the State Health Department early in the process.[3] Then, it became possible to collect data from all hospitals involved within days, by declaring the disaster-related injuries as reportable events. After the Volendam disaster, it took nearly 18 months before data-collection began. In spite of the delay, 100% of the victims were included in the study, which is high compared to the 35–40% inclusion rate in most disaster research projects.[12] It is advisable that agreements are made in advance with the government on their role in the permission for data collection of all hospitals as well as on the financial support of disaster research.

As in this study, a major problem in most disaster research is the lack of available data. The majority of relevant data items were missing in the initial phases of the care process (scene/ambulance, emergency department). Since accurate medical record keeping is critical to the evaluation and effective management of disasters, its importance can not be over-emphasized.[2,12]

A study must be designed in advance and all relevant aspects of the disaster should be evaluated in a integral multidisciplinary and standardized approach.[2] A standard research plan framework should be prepared before a disaster occurs, since there is not enough time to prepare an adequate research plan immediately following a sudden onset disaster. A modular design can be helpful to include all phases of the disaster. The main questions regarding disaster medical care for each step in the medical chain, described in separate modules, could be:

1. What treatment protocols were used?;
2. What was the condition of the patient; and
3. Was medical care provided according to protocol?

It is important to specify these questions early in the process. Then, a selection can be made using relevant, basic parameters. A pilot study should be performed to establish

if these basic parameters and information concerning specific treatments are available. Based on this, the predefined questions can be adapted or specified further. A standard template for disaster research would not be realistic, since injuries can differ in each disaster and different interests might exist.

The Medical Evaluation of the Disaster in Volendam was unique in its organization and structure. After the Oklahoma City bombing, the data collection was combined, but those research studies were fractional and did not included all aspects of medical intervention. In addition, for several of the study protocols, no funding was obtained, which prevented them from commencing.[3]

Conclusion

The evaluation of the Volendam disaster shows that a project approach with a modular design effectively analyzes complex incidents. Due to the multidisciplinary approach, most aspects of medical treatment were covered. The use of several sub-databases makes it easy to combine findings and to conduct cross-sectional and longitudinal analyses. The government has an important role in funding and support of the project. The project team should include experts who understand the methodology of disaster research. A pilot study based on several predefined main questions should be conducted to limit and structure data collection and to support analysis. Then, the questions can be refined and specified further based on the availability of data.

References

1. Sundnes KO, Birnbaum ML (eds): Health Disaster Management Guidelines for Evaluation and Research in the Utstein Style. *Prehosp Disast Med* 2003;17(3):Supplement.
2. Ricci E, Pretto E: Assessment of prehospital and hospital resonse in disaster. *Crit Care Clin* 1991;7:471–484.
3. Quick G: A paradigm for multidisciplinary disaster research: The Oklahoma City experience. *J Emer Med* 1998;16:621–630.
4. Commissie Onderzoek Cafébrand Nieuwjaarsnacht (Commissie Alders): *Cafebrand Nieuwjaarsnacht Eindrapport.* Deen Haag, 2001.
5. Australia and New Zealand Burn Association: *Emergency Management of Severe Burns (EMSB) Course Manual.* NL versie 01/09 edn. 1996.
6. Stuurgroep Medische Evaluatie Ramp Volendam: *Medish Rapport Cafébrand Volendam 2001.* 2003.
7. Stuurgroep Medische Evaluatie Ramp Volendam: *Medish Rapport Cafébrand Volendam 2001 (Fase 2).* 2004.
8. Welling L, van Harten SM, Patka P, *et al*: The cafe fire on New Year's Eve in Volendam, the Netherlands: Description of events. *Burns* 2005;31:548–554.
9. Welling L, van Harten SM, Patka P, *et al*: Medical management after indoor fires: A review. *Burns* 2005;31:673–678.
10. van Harten SM, Welling L, Perez SGM, *et al*: Management of multiple burn casualties from the Volendam disaster in the emergency departmens of general hospitals. *Eur J Emerg Med* 2005;12(6):270–274.
11. Welling L, Perez SGM, van Harten SM, *et al*: Analyis of the pre-event education and subsequent performance of emergency medical responders to the Volendam cafe fire. *Eur J Emerg Med* 2005;12(6):265–269.
12. Lillibridge SR, Noji EK: The importance of medical records in disaster epidemiology research. *J AHIMA* 1992;63:137–138.